GERMINATION OF AECIOSPORES, UREDINIOSPORES, AND TELIOSPORES OF PUCCINIA CORONATA[1]

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During comparatively recent years several workers have contributed considerable information concerning the phenomena of spore germination of crown rust of oats. The data herein recorded were the result of a series of experiments undertaken to determine: (1) the viability of aeciospores collected in several localities on species of *Rhamnus;* (2) the length of time urediniospores from a number of grass hosts, obtained in different localities, would remain viable; (3) the conditions under which urediniospores developed from artificial inoculations of oats in the greenhouse could retain their ability to germinate; (4) the optimum temperature for the germination of viable urediniospores; (5) whether teliospores developed on oat seedlings in the greenhouse would germinate immediately; and (6) how early in the spring teliospores produced in the field on a variety of hosts and collected in various places would germinate.

AECIOSPORE GERMINATION.[2]—From June 22 to July 11 inclusive specimens of rusted *Rhamnus* were collected at Montevideo and Moorehead, Minnesota; Wahpeton, North Dakota; Aberdeen and Brookings, South Dakota; and Beaver Dam, Wisconsin. Immediately following collection in the field, the fresh material was posted to Saint Paul, Minnesota, where the specimens were uniformly packeted in manila envelopes and filed in tin herbarium case boxes. The minimum period from the date of collection to the time the spore germination tests were made was 167 days. Negative results were attendant upon all attempts at germination of the aeciospores from any of the specimens.

[1] Investigations carried on while a graduate student at the University of Minnesota, 1916–1918.

[2] All spore germination tests in these experiments, unless otherwise stated, were made in hanging drops of distilled water in van Tieghem cells at room temperature (about 18°C.).

UREDINIOSPORE GERMINATION.—Rusted specimens of either *Avena fatua*, *A. sativa*, or *A. sterilis* were collected from May 7 to December 15 inclusive at San Diego and Santa Barbara, California; Carrol, Missouri Valley, Onawa, and Sioux City, Iowa; Lexington, Kentucky; Gilliam and Shreveport, Louisiana; Albert Lea, Belle Plaine, Caledonia, Granite Falls, Hinckley, Pipestone, Preston, Saint Paul, Sauk Center, Spring Valley, Two Harbors, Virginia, Wabasha, and Zumbrota, Minnesota; Sedalia and Springfield, Missouri; Pembina, North Dakota; Brookings, Bushnell, and Newell, South Dakota; Jackson, Knoxville, and Nashville, Tennessee; Beaumont and San Antonio, Texas; Lynchburg, Virginia, and Madison, Wisconsin. The freshly acquired material was treated in the same manner as were the specimens of the aeciosporic stage. After a maximum period of 87 days from date of collection, the urediniospores collected on *A. sativa* were still viable. To determine the possibility of differences in the germinating capacity of urediniospores secured on various hosts in different localities, when subjected to similar environmental conditions, the following series of greenhouse inoculations was devised:

a) Rusted specimens of *A. sativa* were collected at Saint Paul, Minnesota. The spores were used as the original inoculum for infecting Improved Ligowa Oats (Minn. 281). Spores obtained as a result of this infection were again used as a source of inoculum for another set of the same host. This procedure was continued for five successive spore generations.

b) Rust collected on *A. sterilis* at Saint Paul, Minnesota, was used as the original inoculum for infecting the same host as that mentioned in the preceding case. The subsequent procedure was the same.

c) The original inoculum for the third series was identical with that described in the second series. The successive inoculations resulted in two spore generations being developed on Improved Ligowa Oats (Minn. 281), one generation on *A. sterilis*, followed by two generations on Improved Ligowa Oats (Minn. 281).

d) Rusted specimens of *A. sterilis* were collected at Lynchburg, Virginia. The spores were used as the original inoculum. Subsequent inoculations resulted in five spore generations being devel-

oped on Improved Ligowa Oats (Minn. 281), one on *A. sterilis*, two on Improved Ligowa Oats (Minn. 281), followed by one generation on *A. sterilis*.

e) Rust collected on *A. sativa* at Lynchburg, Virginia, was used as the original inoculum. Subsequent inoculations resulted in five spore generations being developed on Improved Ligowa Oats (Minn. 281), one on *A. fatua*, followed by two generations on Improved Ligowa Oats (Minn. 281).

f) Rusted specimens of *A. fatua* were collected at San Diego, California. The spores were used as the original inoculum. Subsequent inoculations resulted in thirteen successive spore generations being developed on Improved Ligowa Oats (Minn. 281).

g) Rust collected on *A. sativa* at Tallulah, Louisiana, was used as the original inoculum. Subsequent inoculations resulted in thirteen successive spore generations being developed on Improved Ligowa Oats (Minn. 281).

Heavily rusted leaves were cut from plants in each series and placed in Petri dishes. Germination tests showed the spores from each series to be viable when removed from the greenhouse. The following environmental conditions were provided:

A. Petri dishes were placed outside and protected by covering with about one foot of leaves and snow.

B. Petri dishes were placed outside and not afforded any protection.

C. Petri dishes were wrapped in heavy manila paper and placed in a dark cabinet drawer, indoors.

D. Petri dishes were placed indoors fully exposed to sunlight.

Material from series *a*, *b*, *f*, and *g* was subjected to environment *A;* from series *a*, *e*, *f*, and *g* to environment *B;* from series *b* and *g* to environment *C;* from series *c* and *g* to environment *D*. Series *a*, *c*, *e*, *f*, and *g* under all of the environmental conditions and series *g* under environments *A*, *B*, and *D* gave no positive germination tests. The germination tests from series *b* under all environments provided, of series *d* under environment *A*, and of series *g* under environment *C* were all positive. The temperature range for environments out-of-doors was between −27° F. and 42° F. inclusive, while for the indoors environments it was between 29° F. and

86° F. inclusive. No consistent differences as to viability of spores from various hosts and with different greenhouse life histories were noted.

Specimens of rusted *A. sativa* were collected at Saint Paul, Minnesota. Attempts were made to germinate spores at different temperatures, which resulted in positive germination tests at relatively low temperatures (about 7°C.), although apparently not above 32°C. A temperature of about 18°C. seemed to be the optimum.

JOHNSON,[3] in his germination studies of uredospores of crown rust of oats, came to similar conclusions. He gave 7°–8°C. as the minimum, 30°C. as the maximum, and 12°–17°C. as the optimum for germination.

TELIOSPORE GERMINATION.—Uredinial material collected from January 21 to April 20 on *A. sativa* and *A. sterilis* at Saint Paul, Minnesota, was used as the original source of inoculum from which sixteen different series of seedling oat hosts in the greenhouse were infected. Plants of each series produced telia in abundance. Negative results were obtained in all attempts to germinate these teliospores. Rusted specimens of either *A. sativa* or *A. sterilis* were collected from May 19 to May 2 of the year following, at Baton Rouge, Louisiana, and Olivia, Rochester, and Saint Paul, Minnesota. All attempts at germination gave negative results.

Summary

1. Aeciospores from herbarium specimens of *Rhamnus* were not viable after a period of 167 days from date of collection.

2. Urediniospores from herbarium specimens of *Avena sativa* proved to be viable as long as 87 days after date of collection.

3. Unprotected urediniospores lost their viability within 22 days, with a minimum temperature, during this period, of −27°F. and a maximum of 42°F.

4. When afforded protection with a temperature range similar to the unprotected, these spores remained viable as long as 44 days.

5. Exposed to light, viability of urediniospores was lost within

[3] JOHNSON, E. C., Cardinal temperatures for the germination of uredospores of cereal rust. Phytopath. 2:47, 48. 1912.

23 days, during which period the maximum temperature was 86° F. and the minimum 29° F.

6. Kept in the dark, urediniospores at similar temperatures to those exposed to light, remained viable as long as 79 days.

7. Urediniospores germinated at a temperature as low as 7° C., with an optimum of 18° C., and a maximum of 32° C.

8. Teliospores developed on oat seedlings in the greenhouse and not afforded a period of overwintering did not germinate.

9. Previous to overwintering and as late in the spring as May 2, teliospores developed in the field were incapable of germination.

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